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Description

The invention relates to attenuated bacteria for use in animal and human medicine and to pharmaceutical compositions containing them.

In 1950 Bacon et al (Br.J.Exp.Path. 31, 714-724) demonstrated that certain auxotrophic mutants of S.typhi were attenuated in mice when compared to the parental strain. Certain of these auxotrophic mutants have been proposed as being suitable candidates for the basis of a whole cell vaccine. (See for example Hosieth and Stocker (Nature 241, 238-39, UK patent application 87/30037, The Wellcome Foundation)).

Together with envZ, ompR forms a two gene operon, previously designated ompB. The nucleotide sequence of this locus is highly conserved between Escherichia coli and Salmonella typhimurium. The ompR gene is primarily concerned with the regulation of osmotically-responsive genes and acts in concert with envZ. ompR and envZ genes form a single transcription unit with translationally -coupled expression (Liljestrom et al., J.Mol.Biol. 201, 663-673 1988). OmpR has been identified as a positive activator of gene expression (Jo et al. J.Bacteriol, 140, 843-847; Norioka et al J.Biol.Chem, 261 15252 1986) while EnvZ has been shown to be associated with the inner membrane (Forst et al., J.Biol.Chem. 262 16433 1987). It has been proposed that EnvZ acts as an environmental sensor and transmits signals to OmpR, modulating the transcriptional control activity of the latter (Hall and Silhavy, J.Mol.Biol. 151 1 1981). A pleiotropic mutation in envZ has been shown to be suppressed by a mutation in ompR, providing genetic evidence that the products of these genes functionally interact (Matsuyama et al., J.Bacteriol 168 1309-1314 1986). Moreover, suppressor mutations of envZ have been mapped to rpoA, the gene coding for the A subunit of RNA polymerase. This suggests that OmpR and RNA polymerase interact (Garrett and Silhavy, J.Bacteriol 169 1379 1987; Matsuyama and Mizushima, J.Mol.Biol. 195 847 1987). The genes which are ompR dependent for transcription are primarily those coding for the major outer membrane porins OmpC and OmpF, although expression of the S.typhimurium tppB operon, coding for a tripeptide permease, has been reported to be OmpR-dependent (Gibson et al Mol. Gen. Genet. 297 120-129 1987). Ikenada et al (Mol. Gen. Genet. 211 538-540 1988) identified a dominant mutation in E.coli ompR which prevents activation of porin expression. Binding sites for OmpR have been biochemically identified upstream of the ompC and ompF promoters (Norioka et al., supra). Expression of these genes is reciprocally regulated by growth medium osmolarity in an OmpR-dependent manner (Aiba et al., J.Bacteriol 169 3007 1987; Kawaji et al., J.Bacteriol 140 843-847 1979; Mizuno, PNAS(USA) 81 1966-70 1987; van Alphen and Lutenberg, J.Bacteriol 131 625-630 1977). In growth media of high osmolarity, the level of OmpC is elevated while that of OmpF is repressed; in media of low osmolarity, the reverse is true.

The present inventors have found that it is possible to attenuate pathogenic bacteria by introducing a mutation into the ompR gene. Thus, according to the present invention there is provided a vaccine formulation comprising a bacterium attenuated by a non-reverting mutation in the ompR gene in admixture with a pharmaceutically acceptable excipient.

The attenuated bacteria are preferably Gram-negative bacteria which can invade and grow within eucaryotic cells and colonise the mucosal surface. Examples of these include members of the genera Salmonella, Bordetella, Vibrio, Haemophilus, Escherichia. In particular the following species can be particularly mentioned; S.typhi -the cause of human typhoid; S.typhimurium - the cause of salmonellosis in several animal species; S.enteritidis - a cause of food poisoning in humans; S.cholerae-suis - the cause of salmonellosis in pigs; Bordetella pertussis - the cause of whooping cough; Haemophilus influenzae - a cause of meningitis; and Neisseria gonorrhoeae - the cause of gonorrhoea.

If an attenuated microorganism is to be used in a live form in a vaccine preparation, it is clearly important that such a microorganism does not revert back to the virulent parent. The probability of this happening with a single mutation is considered to be small; however, the risk of reversion occuring in a strain harbouring mutations in two discrete genes, located in different places in the genome, is considered to be insignificant.

The present invention also provides a vaccine formulation comprising an attenuated bacterium harbouring a mutation in the ompR gene and a second mutation in a second gene. Preferably the second gene is a gene encoding for an enzyme involved in an essential biosynthetic pathway, in particular genes involved in the pre-chorismate pathway involved in the biosynthesis of aromatic compounds. The mutations will preferably be in aroA (the gene encoding 5-enolpyruvyl shikimate-3-phosphate synthase), aroC (chorismate synthase), aroD (3-dehydroquinase) or aroE.

The attenuated bacteria are constructed by the introduction of a stable mutation into the ompR gene. These mutations may be made by any method known to those skilled in the art. In one embodiment non-reverting mutations were generated by transducing an LT2 ompR::Tn10 marker into S.typhi and S.typhimurium strains. Tn10 transposon carries a gene encoding for tetracycline resistance. Transductants

are selected that are tetracycline resistant by growing colonies on an appropriate medium. Further selection is undertaken by screening for those organisms which have lost the tetracycline resistance gene and which derepressed a tppB::Mud1-8 (lac fusion) under anaerobic growth conditions.

Alternative methods for generating non-reverting mutations include cloning the ompR gene into a vector, eg a plasmid or cosmid, and incorporating a selectable marker gene into the cloned gene, at the same time inactivating the gene. A plasmid carrying the inactivated gene and a different selectable marker can be introduced into the organism by known techniques. It is then possible by suitable selection to identify a mutant wherein the inactivated gene has recombined into the organism's own chromosome and the organism's own copy of the gene has been lost. In particular, the vector used is one which is unstable in the organism (ie. a 'suicide' vector) and will be spontaneously lost. The mutated gene on the plasmid and the organisms own copy of the gene on its chromosome may be exchanged by a genetic cross-over event.

Additional methods eliminate the introduction of foreign DNA into vaccine strains at the site of mutations. This can be achieved by cloning the target organism's native gene into a suitable suicide vector (carrying a drug resistance marker) as described above but making a defined deletion in the gene (inactivating it) rather than introducing a selectable marker. This can be introduced into the target organism and the initial selection is made for a single crossover (ie. the organism is drug resistant). Subsequent growth of the strain in the absence of antibiotic and screening of several thousand colonies allows identification of drug sensitive organisms. This may occur in two ways: i) the vector harbouring the deleted gene is lost, ie. the organism is wild type and ii) a second recombination event (resulting in a double crossover) has occured resulting in the replacement of the wild type gene with the deleted gene. We have developed a novel method for screening for the presence of the deletion using the polymerase chain reaction (PCR). Oligonucleotides are synthesised corresponding to regions either side of the deleted region and are used as primers for PCR to amplify the deleted regions from drug sensitive colonies. The amplified product can be analysed by agarose gel electrophoresis. It is possible to distinguish strains harbouring a deleted region as the PCR product is smaller for the deleted gene than for the wild type gene. The PCR product can also be directly sequenced allowing the deletions to be completely defined.

The strains used in the present invention may be genetically engineered so as to express antigens from one or more different pathogens. The invention includes a vaccine formulation wherein the attenuated bacterium is transformed with an expression cassette comprising a gene encoding an antigen from a heterologous pathogen. Such pathogens, may be viral, bacterial, protozoal or of higher parasitic organisms. The pathogens may infect both humans and other mammals, but may be species selective, or even species specific. Such strains could then form the basis of a bi or multivalent vaccine. Examples of useful antigens include E. coli heat labile toxin B subunit (LT-B), E. coli K88 antigens, FMDV (Foot and Mouth) peptides, Influenza viral proteins, 69Kd protein from B.pertussis, C fragment from tetanus toxin of C.tetani. Other antigens which could be usefully expressed would be those from Chlamydia, flukes, mycoplasma, round-worms, tapeworms, rabies virus and rotavirus.

These antigens may be produced by the introduction of the gene or genes encoding them into expression cassettes. Expression cassettes will include DNA sequences, in addition to that coding for the structural gene, which will encode for transcriptional and translational initiation and termination regions. The expression cassette may also include regulatory regions. Such expression cassettes are well known in the art and it is well within the skill of the skilled man to construct them. The expression cassette may be a construct or a naturally occuring plasmid. An example of a genetically engineered attenuated Salmonella which expresses a foreign antigen can be found in EP application No. 0 127 153 A (SSVI/Wellcome). The expression cassette may also be engineered to allow the incorporation of the heterologous gene into the bacterial chromosome, making use of the suicide vector and PCR techniques as previously described and introducing the DNA encoding for foreign antigen into a suitable gene such as ompR, aroA, C or D.

A further bivalent vaccine comprising an attenuated Salmonella typhi, capable of expressing the E.coli heat-labile enterotoxin subunit B, was disclosed by Clements et al (Infection and Immunity, 46, No. 2., Nov 1984, p564-569). Ty21a has been used to express other antigens such as the Shigella sonnei form I antigen (Formal et al, Infection and Immunity 34 746-750).

The vaccine of the invention is advantageously presented in a lyophilised form, for example in a capsular form, for oral administration to a patient. Such capsules may be provided with an enteric coating comprising for example Eudragate "S" Eudragate "L" Cellulose acetate, cellulose pthalate or hydroxy propylmethyl cellulose. These capsules may be used as such, or alternatively, the lyopholised material may be reconstituted prior to administration, e.g. as a suspension. Reconstitution is advantageously effected in a buffer at a suitable pH to ensure the viability of the organisms. In order to protect the attenuated bacteria and the vaccine from gastric acidity, a sodium bicarbonate preparation is advantageously administered before each administration of the vaccine. Alternatively the vaccine may be prepared for parenteral

administration, intranasal administration or intramammary.

The present invention also provides an attenuated bacterium as described above for use in medical therapy, for example for use in the prophylactic treatment of a bacterial infection. The dosage employed will be dependent on various clinical factors, including the size and weight of the patient, and the type of vaccine formulated. However, for attenuated S. typhi a dosage comprising the administration of 10^9 to 10^{11} S. typhi organisms per dose is generally convenient for a 70kg adult human patient.

In the following, examples are provided of experimental details in accordance with the present invention. It will be understood that these examples are not intended to limit the invention in any way.

Example 1

Construction of OmpR mutants in S.typhimurium. S.dublin.

An OmpR deletion was introduced into S.typhimurium SL1344, and S.dublin using phage P22 (available from Dr. T. Foster, Trinity College, Dublin) transduction. A phage lysate prepared on strain CJD359 was used to transduce all the Salmonella strains, selecting for tetracycline-resistant colonies. Strain CJD359 carries Tn10 inserted in the ompR gene. In order to ensure that the strains were of the OmpR phenotype, P22 lysates were prepared on each strain and used to transduce strain CH776 (available from Prof.C.F.Higgins, ICRF Laboratories, Institute of Molecular Medicine, John Radcliffe Hospital, Oxford, OX3 9DU) which carries a tppB::Mud1-8 (lac) fusion. The strain was checked for derepression of the fusion under anaerobic growth conditions after transduction with the P22 lysates. One isolate from each strain was used to prepare tetracycline-sensitive derivatives by selection on Bochner medium. Several of these were purified and checked for the ompR deletion using PCR technique described above.

An S.typhimurium ompR$^-$ (BRD 578) strain has been deposited at National Collection of Type Cultures, 61 Colindale Avenue, London, NW9 5HT, UK under No. NCTC 12396 on 25th May 1990. An S.dublin (BRD 579) ompR$^-$ strain has been deposited at National Collection of Type Cultures, 61 Colindale Avenue, London, NW9 5HT, UK under No. NCTC 12398 on 25th May 1990.

Example 2

Construction of aroA OmpR mutants in S.typhimurium, and S.dublin.

An aroA deletion was introduced into S.typhimurium SL1344, and S.dublin. using the method of McFarland and Stocker. A phage lysate prepared from strain TT472 (available from Dr. B.A.D. Stocker, Stanford University, California) was used to transduce all the Salmonella strains, selecting for tetracycline-resistant colonies. Strain TT472 carries Tn10 inserted within serC which is upstream of and within the same operon as aroA. Tetracycline-resistant transductants were aromatic compound, serine and pyridoxine dependent. A second P22 lysate was prepared, grown on SL5254, (available from Dr. B.A.D. Stocker, Stanford University, California) which has a known deletion within aroA. This was used to transduce the tetracycline resistant strains which were serC:: Tn10 and transductants were selected on minimal medium lacking serine and pyridoxine but containing aromatic compounds but in the absence of serine and pyridoxine were tetracycline-sensitive and aromatic compound dependent.

An OmpR deletion was then introduced into all the strains using the method described in example 1.

An S.typhimurium (BRD 731) ompR$^-$ aroA$^-$ strain has been deposited at National Collection of Type Cultures, 61 Colindale Avenue, London, NW9 5HT, UK under No. NCTC 12397 on 25th May 1990. An S.dublin (BRD 582) ompR$^-$ aroA$^-$ strain has been deposited at National Collection of Type Cultures, 61 Colindale Avenue, London, NW9 5HT, UK under No. NCTC 12399 on 25th May 1990.

Example 3

Construction of Salmonella typhi OmpR mutant

An ompR deletion was introduced into S.typhi Ty2 as described in example 1. In order to ensure that the strain was of the OmpR phenotype a P22 lysate was prepared on strain CH776 which carries a tppB::Mud1-8 (lac fusion), and transduced into the S.typhi strain. The strain was then tested for derepression of the fusion under anaerobic growth conditions.

Example 4

Construction of S.typhi aroA ompR mutant

S.typhi Ty2 aroA was prepared as follows: A cosmid bank of S.typhi was constructed into λ phage, and used to transduce a well characterised aroA mutant of E.coli. This facilitated the isolation of an aroA clone of S.typhi. Subsequent mapping and sequence analysis allowed the identification of convenient restruction sites which were used to construct a defined deletion. The aroA gene harbouring the deletion was introduced into the suicide vector gP704 and a method developed for electroporating into S.typhi. The drug resistant colonies were grown in the absence of antibiotics and drug sensitive variants isolated. These were screened for their dependence an aromatic compounds for growth in vitro. A colony that was dependent on these compounds for growth was analysed using Southern hybridisation and PCR confirming the deletion in aroA and absence of any vector DNA. An ompR deletion was introduced into this strain as described in Example 3.

S.typhi (BRD 732) ompR$^-$ aroA$^-$ was deposited at National Collection of Type Cultures, 61 Colindale Avenue, London, UK, under Accession no. NCTC 12395 on 25th May 1990.

Example 5

Comparison of attentuation Salmonella typhimurium CJD 359 (ompR) with virulent parent strain, Salmonella typhimurium SL 1344.

The CJD359 strain (now BRD 578) was constructed using transposon-linked mutations into S.typhimurium SL1344 using bacteriophage P22-mediated transduction, as described in Example 1.

Infection of mice and enumeration of bacteria in murine organs.

BALB/c males of 8-10 weeks of age were used throughout, bred in the animal unit at Wellcome Research Laboratories from breeders originally purchased for OLAC (1976) UK Ltd (Black, Bicester, Oxfordshire, UK). Livers, spleens, mesenteric lymph nodes and Peyer's patches were homogenised as previously described, Mashell et al 1987 Microb.Pathogen, 3, 129-141. Viable counts were performed on these homogenates using L-agar as growth medium. Counts are shown in the figures as geometric means 1 standard errors (n = 4 mice per point). For oral inoculation into mice bacteria were grown statically at 37° overnight in 2 litres of L-broth. The culture was centrifuged and the bacterial pellet was resuspended in its own volume and diluted in phosphate buffered salines (pH 7.2) as required. Bacteria in 0.2ml were administered in 0.2ml volumes orally to lightly anaethetised mice by gavage needle. The inoculum was calculated by plating appropriate dilutions on L-agar pour plates. For intravenous (iv.) inoculation, mice were injected with 0.2ml of bacterial suspension into the tail vein. Deaths were recorded over the following four weeks and the LD_{50} was calculated by the method of Reed and Muench 1938 Am.J.Hyg, 27, 493-497.

After oral administration CJD359 had an LD_{50} of greater 9.64 log units as compared to the parental strain, SL 1344, which has an LD_{50} of 6.38 log units. (All LD_{50} were calculated after 28 days). Thus CJD359 is highly attenuated. After iv. administration CJD359 had an iv. LD_{50} of Log 5.13 compared to < Log 10 for SL1344 and we again conclude that CJD359 is highly attenuated compared to SL1344.

In vivo growth pattern of CJD359 after oral and iv administration to BALB/c mice.

The ability of SL13444 and CJD359 to grow in vivo after oral or iv administration was assessed. For the iv experiment the numbers of viable organisms in the livers and spleens at different days after challenge were assessed (Fig 1a). After iv administration of Log 3.7 SL1344 the strain grew rapidly in livers and spleen and all mice died within seven days of challenge. After administration iv of Log 4.2 CJD359 a level of about 10% of the inoculum was detected in the livers and spleens 24 hours later. After this initial drop CJD359 appeared to grow slowly reaching a maximal level of about Log 5 organisms by day 14 and was then slowly cleared. All mice challenged iv with CJD359 exhibited a pronounced splenomegaly during the early phases of the infection. Log 9.8 SL1344 and Log 9.5 CJD359 organisms were administered orally to BALB/c mice and the levels of organisms were assessed in livers, spleens, peyers patches and mesenteric lymph nodes at different times after challenge. Again CJD359 exhibited an impaired ability to grow in vivo compared to SL1344 (Fig 1b). SL1344 invaded the tissues of all mice challenged and grew rapidly until all mice had died within 14 days of challenge. CJD359 was also able to invade and organisms were detected

in peyers patches and mesenteric lymph nodes by day 1 post challenge. By day 4 bacteria had reached liver and spleen and attained a maximal level of colonisation of the host tissue around day 7. Thereafter CJD359 was slowly cleared from the tissues.

Protection of mice after oral challenge.

Mice were immunised with Log 10^{10} CJD359 and challenged 28 days later with the virulent parental strain SL1344. Mice vaccinated with CJD359 showed excellent protection against challenge with SL1344. The LD_{50} in immunised animals was >Log 9.64 compared with Log 5.64 for unimmunised controls. Thus mice vaccinated orally with CJD359 were well protected against virulent SL1344 challenge.

Example 6: Formulation

An attenuated bacterium of the present invention is preferably presented in oral tablet form.

Ingredient	mg/tablet
Core-tablets	
1) Freeze-dried excipient carrier containing 10^9-10^{10} attenuated bacteria	70.0
2) Silica dioxide (Aerosil 200*)	0.5
3) Dipac* (97% sucrose)	235.0
4) Cross-linked Povidone (Kollidon CL*)	7.0
5) Microcrystalline Cellulose (Avicel pH 102*)	35.0
6. Magnesium Stearate	2.5
	350.0
Coating	
7) Opadry Enteric, OY-P-7156 (Polyvinyl acetate phthalate + Diethylphthate)	35.0
	385.0
An asterisk (*) indicates a Trade Name	

A carrier containing 5% sucrose 1% sodium glutamate and 1% bacto casitone in an aqueous solvent is prepared. The organisms are suspended in this carrier and then subjected to freeze-drying.

The freeze-dried material is blended with Aerosil 200 and the blended mixture is sifted through a screen. The sifted powder is mixed with Dipac, Kollidan CL, Aricel pH 102 and Magnesium Stearate in a blender. This blend is compressed into tablets for subsequent enteric coatings.

The skilled man will appreciate that many of the ingredients in this formulation could be replaced by functionally equivalent pharmaceutically acceptable excipients.

Claims

Claims for the following Contracting States : AT, BE, CH, DE, DK, FR, GB, IT, LI, LU, NL, SE

1. A vaccine formulation comprising a bacterium attenuated by a non-reverting mutation in the ompR gene in admixture with a pharmaceutically acceptable excipient.

2. A formulation according to claim 1 wherein the attenuated bacterium is a gram negative bacterium.

3. A formulation according to claim 1 wherein the attenuated bacterium is selected from the genera Salmonella, Bordetella, Vibrio, Haemophilus and Escherichia.

4. A formulation according to claim 1 wherein the attenuated bacterium is selected from Salmonella typhi, Salmonella typhimurium, Salmonella enteriditidis, Salmonella cholerae-suis, Bordetella pertussis, Haemophilus influenzae and Neisseria gonorrhoeae.

5. A formulation according to any one of the preceding claims wherein the attenuated bacterium additionally harbours a second mutation in a second gene.

6. A formulation according to claim 5 wherein the second mutation is in an essential auxotrophic pathway.

7. A formulation according to claim 6 wherein the second mutation is in a gene encoding an enzyme in an aromatic pathway.

8. A formulation according to claim 7 wherein the second mutation is in a gene selected from aroA, aroC, aroD and aroE.

9. A formulation according to claim 1 wherein the attenuated bacterium is selected from Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$, and Salmonella dublin aroA$^-$ ompR$^-$.

10. A formulation according to any one of the preceding claims wherein the attenuated bacterium is transformed with an expression cassette comprising a gene encoding an antigen from a heterologous pathogen.

11. A bacterium attenuated by a non-reverting mutation in the ompR gene as defined in any one of the preceding claims, for use in medical therapy.

12. A bacterium according to claim 11 for use in prophylactic treatment of a bacterial infection.

13. Use of a bacterium attenuated by a non-reverting mutation in the ompR gene as defined in any one of the preceding claims, in the manufacture of a medicament for prophylactic treatment of a bacterial infection.

Claims for the following Contracting States : ES, GR

1. A process for precaring a vaccine formulation, which process comprises formulating a bacterium attenuated by a non-reverting mutation in the ompR gene with a pharmaceutically acceptable excipient.

2. A process according to claim 1 wherein the attenuated bacterium is a gram negative bacterium.

3. A process according to claim 1 wherein the attenuated bacterium is selected from the genera Salmonella, Bordetella, Vibrio, Haemophilus and Escherichia.

4. A process according to claim 1 wherein the attenuated bacterium is selected from Salmonella typhi, Salmonella typhimurium, Salmonella enteriditidis, Salmonella cholerae-suis, Bordetella pertussis, Haemophilus influenzae and Neisseria gonorrhoeae.

5. A process according to any one of the preceding claims wherein the attenuated bacterium additionally harbours a second mutation in a second gene.

6. A process according to claim 5 wherein the second mutation is in an essential auxotrophic pathway.

7. A process according to claim 6 wherein the second mutation is in a gene encoding an enzyme in an aromatic pathway.

8. A process according to claim 7 wherein the second mutation is in a gene selected from aroA, aroC, aroD and aroE.

9. A process according to claim 1 wherein the attenuated bacterium is selected from Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$, and Salmonella dublin aroA$^-$ ompR$^-$.

10. A process according to any one of the preceding claims wherein the attenuated bacterium is transformed with an expression cassette comprising a gene encoding an antigen from a heterologous pathogen.

Patentansprüche

Patentansprüche für folgende Vertragsstaaten : AT, BE, CH, DE, DK, FR, GB, IT, LI, LU, NL, SE

1. Impfstoff-Formulierung, umfassend ein durch eine nicht-reversible Mutation im ompR-Gen abgeschwächtes Bakterium in Mischung mit einem pharmazeutisch annehmbaren Träger.

2. Formulierung nach Anspruch 1, worin das abgeschwächte Bakterium ein gram-negatives Bakterium ist.

3. Formulierung nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus den Stämmen Salmonella, Bordetella, Vibrio, Haemophilus und Escherichia.

4. Formulierung nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus Salmonella typhi, Salmonella typhimurium, Salmonella enteritidis, Salmonella cholerae-suis, Bordetella pertussis, Haemophilus influenzae und Neisseria gonorrhoeae.

5. Formulierung nach einem der vorhergehenden Ansprüche, worin das abgeschwächte Bakterium zusätzlich eine zweite Mutation in einem zweiten Gen enthält.

6. Formulierung nach Anspruch 5, worin die zweite Mutation in einem essentiellen auxotrophen Biosyntheseweg vorliegt.

7. Formulierung nach Anspruch 6, worin die zweite Mutation in einem Gen vorliegt, das für ein Enzym in einem Aromaten-Stoffwechselweg kodiert.

8. Formulierung nach Anspruch 7, worin die zweite Mutation in einem Gen, ausgewählt aus aroA, aroC, aroD und aroE vorliegt.

9. Formulierung nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$ und Salmonella dublin aroA$^-$ ompR$^-$.

10. Formulierung nach einem der vorhergehenden Ansprüche, worin das abgeschwächte Bakterium mit einer Expressionskassette, umfassend ein für ein Antigen aus einem heterologen Pathogen kodierendes Gen, transformiert ist.

11. Bakterium, abgeschwächt durch eine nicht-reversible Mutation im ompR-Gen gemäß einem der vorhergehenden Ansprüche, zur Verwendung bei der medizinischen Therapie.

12. Bakterium nach Anspruch 11 zur Verwendung bei der prophylaktischen Behandlung einer bakteriellen Infektion.

13. Verwendung eines durch eine nicht-reversible Mutation im ompR-Gen gemäß einem der vorhergehenden Ansprüche abgeschwächten Bakteriums für die Herstellung eines Medikaments für die prophylaktische Behandlung einer bakteriellen Infektion.

Patentansprüche für folgende Vertragsstaaten : ES, GR

1. Verfahren zur Herstellung einer Impfstoff-Formulierung, wobei das Verfahren die Formulierung eines durch eine nicht-reversible Mutation im ompR-Gen abgeschwächten Bakteriums mit einem pharmazeutisch annehmbaren Exzipienten umfaßt.

2. Verfahren nach Anspruch 1, worin das abgeschwächte Bakterium ein gram-negatives Bakterium ist.

3. Verfahren nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus den Stämmen Salmonella, Bordetella, Vibrio, Haemophilus und Escherichia.

4. Verfahren nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus Salmonella typhi, Salmonella typhimurium, Salmonella enteritidis, Salmonella cholerae-suis, Bordetella pertussis, Haemo-

philus influenzae und Neisseria gonorrhoeae.

5. Verfahren nach einem der vorhergehenden Ansprüche, worin das abgeschwächte Bakterium zusätzlich eine zweite Mutation in einem zweiten Gen enthält.

6. Verfahren nach Anspruch 5, worin die zweite Mutation in einem essentiellen auxotrophen Biosyntheseweg vorliegt.

7. Verfahren nach Anspruch 6, worin die zweite Mutation in einem Gen vorliegt, das für ein Enzym in einem Aromaten-Stoffwechselweg kodiert.

8. Verfahren nach Anspruch 7, worin die zweite Mutation in einem Gen, ausgewählt aus aroA, aroC, aroD und aroE vorliegt.

9. Verfahren nach Anspruch 1, worin das abgeschwächte Bakterium ausgewählt ist aus Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$ und Salmonella dublin aroA$^-$ ompR$^-$.

10. Verfahren nach einem der vorhergehenden Ansprüche, worin das abgeschwächte Bakterium mit einer Expressionskassette, umfassend ein für ein Antigen aus einem heterologen Pathogen kodierendes Gen, transformiert ist.

Revendications

Revendications pour les Etats contractants suivants : AT, BE, CH, DE, DK, FR, GB, IT, LI, LU, NL, SE

1. Formulation de vaccin comprenant une bactérie atténuée par une mutation non réversible dans le gène ompR en mélange avec un excipient pharmaceutiquement acceptable.

2. Formulation selon la revendication 1 dans laquelle la bactérie atténuée est une bactérie à Gram négatif.

3. Formulation selon la revendication 1 dans laquelle la bactérie atténuée est choisie parmi las genres Salmonella, Bordetella, Vibrio, Haemophilus et Escherichia.

4. Formulation selon la revendication 1 dans laquelle la bactérie atténuée est choisie parmi Salmonella typhi, Salmonella typhimurium, Salmonella enteriditidis, Salmonella cholerae-suis, Bordetella pertussis, Haemophilus influenzae et Neisseria gonorrhoeae.

5. Formulation selon l'une quelconque des revendications précédentes dans laquelle la bactérie atténuée porte en outre une seconde mutation dans un second gène.

6. Formulation selon la revendication 5 dans laquelle la seconde mutation est dans une voie métabolique essentielle d'auxotrophie.

7. Formulation selon la revendication 6 dans laquelle la seconde mutation est dans un gène codant pour une enzyme dans une voie métabolique impliquant un composé aromatique.

8. Formulation selon la revendication 7 dans laquelle la seconde mutation est dans un gène choisi parmi aroA, aroC, aroD et aroE.

9. Formulation selon la revendication 1 dans laquelle la bactérie atténuée est choisie parmi Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$, et Salmonella dublin aroA$^-$ ompR$^-$.

10. Formulation selon l'une quelconque des revendications précédentes dans laquelle la bactérie atténuée est transformée avec une cassette d'expression comprenant un gène codant pour un antigène d'un pathogène hétérologue.

11. Bactérie atténuée par une mutation non réversible dans le gène ompR tel que défini dans l'une quelconque des revendications précédentes, pour utilisation dans une thérapie médicale.

12. Bactérie selon la revendication 11 pour utilisation dans un traitement prophylactique d'une infection bactérienne.

13. Utilisation d'une bactérie atténuée par une mutation non réversible dans le gène ompR tel que défini dans l'une quelconque des revendications précédentes, dans la préparation d'un médicament pour le traitement prophylactique d'une infection bactérienne.

Revendications pour les Etats contractants suivants : ES, GR

1. Procédé de préparation d'une formulation de vaccin, procédé qui comprend la formulation d'une bactérie atténuée par une mutation non réversible dans le gène ompR avec un excipient pharmaceutiquement acceptable.

2. Procédé selon la revendication 1 dans lequel la bactérie atténuée est une bactérie à Gram négatif.

3. Procédé selon la revendication 1 dans lequel la bactérie atténuée est choisie parmi les genres Salmonella, Bordetella, Vibrio, Haemophilus et Escherichia.

4. Procédé selon la revendication 1 dans lequel le bactérie atténuée est choisie parmi Salmonella typhi, Salmonella typhimurium, Salmonella enteriditidis, Salmonella cholerae-suis, Bordetella pertussis, Haemophilus influenzae et Neisseria gonorrhoeae.

5. Procédé selon l'une quelconque des revendications précédentes dans lequel le bactérie atténuée porte en outre une seconde mutation dans un second gène.

6. Procédé selon la revendication 5 dans lequel la seconde mutation est dans une voie métabolique essentielle d'auxotrophie.

7. Procédé selon le revendication 6 dans lequel la seconde mutation est dans un gène codant pour une enzyme dans une voie de synthese d'un composé aromatique.

8. Procédé selon la revendication 7 dans lequel la seconde mutation est dans un gène choisi parmi aroA, aroC, aroD et aroE.

9. Procédé selon la revendication 1 dans lequel la bactérie atténuée est choisie parmi Salmonella typhi ompR$^-$, Salmonella typhimurium ompR$^-$, Salmonella dublin ompR$^-$, Salmonella typhi aroA$^-$ ompR$^-$, Salmonella typhimurium aroA$^-$ ompR$^-$, et Salmonella dublin aroA$^-$ ompR$^-$.

10. Procédé selon l'une quelconque des revendications précédentes dans lequel le bactérie atténuée est transformée avec une cassette d'expression comprenant un gène codant pour un antigène d'un pathogène hétérologue.

Fig.1(a).

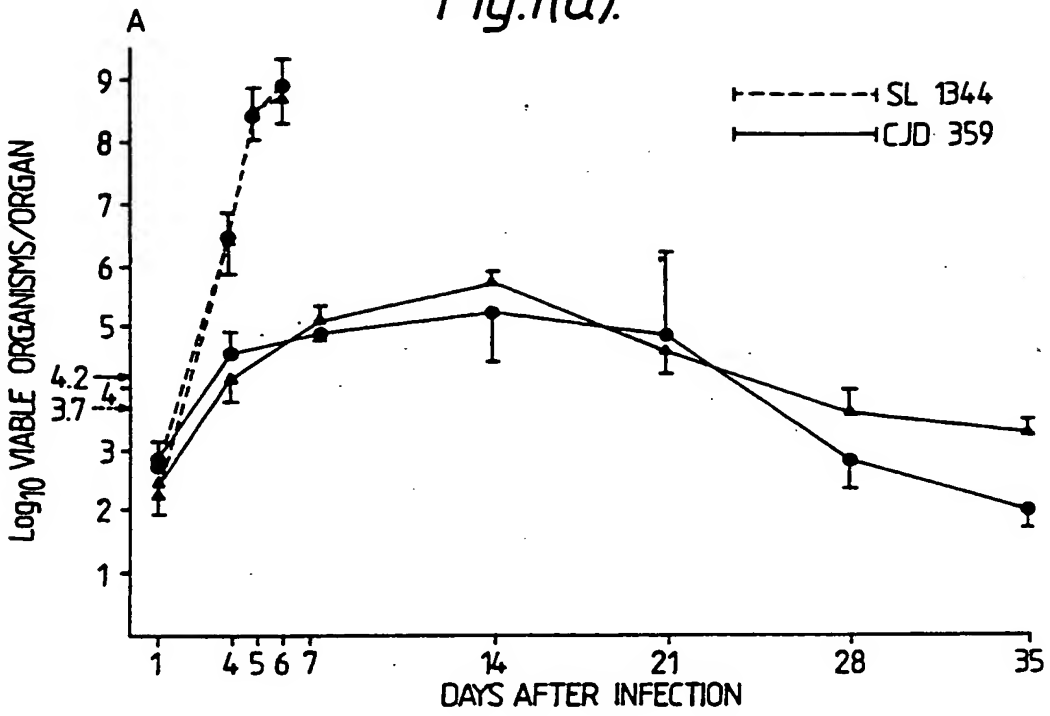
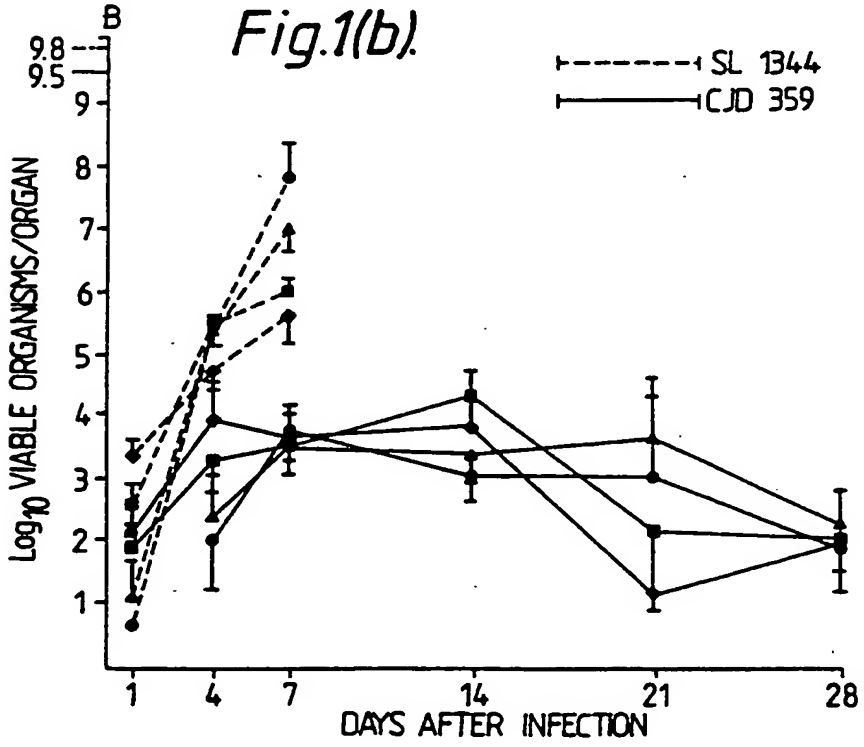

A
SL 1344
CJD 359
Log10 VIABLE ORGANISMS/ORGAN
9
8
7
6
5
4.2
3.7
4
3
2
1
1
4
5
6
7
14
21
28
35
DAYS AFTER INFECTION

Fig.1(b).


B
SL 1344
CJD 359
Log10 VIABLE ORGANISMS/ORGAN
9.8
9.5
9
8
7
6
5
4
3
2
1
1
4
7
14
21
28
DAYS AFTER INFECTION